# PROCEEDINGS

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# Feasibility of Multicomponent T2 Relaxation Analysis using Data Measured on Clinical MR Scanners

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Although analysis of the multiple relaxation components that characterize tissue T2 decay is a major focus of NMR relaxometry, the relative contributions and T2 values of the components for a given tissue remain poorly understood. Ideally, multicomponent T2 relaxation analysis could provide subtle optimization of contrast in MR images, and tissue-specific information that is currently unobtainable by other non-invasive methods. For example, recent studies have indicated that the bulk T2 relaxation properties of breast tissue have potential for assessment of breast cancer risk in asymptomatic women[1], and that the relative fraction of the short T2 component of white matter may be a predictor of multiple sclerosis[2]. To achieve the potential of these findings, accurate multicomponent T2 analysis must be possible from data measured *in vivo* using clinical MR scanners.

Tissue relaxometry has conventionally been performed on excised samples using modified NMR spectrometers, where it is possible to achieve very high signal to noise ratios (> 500) and a large number of echoes (> 100). These stringent experimental conditions are necessary because the fitting of relaxation data with a small number of exponentials is a difficult inverse problem. Conventional, non-linear least squares algorithms are susceptible to noise and require *a priori* assumptions of the number of relaxation components present. The non-negative least squares algorithm modified by Whittall (T2NNLS) removes these assumptions and provides a robust, constrained fit of the relaxation data to a smooth distribution of relaxation times[3]. Distributions of relaxation times are also more likely to be appropriate models of tissue heterogeneity. We have used numerical simulations to investigate whether analysis using T2NNLS can be achieved under the more limited experimental conditions common to clinical MR scanners.

Simulated data were generated according to reported values for bulk breast tissue[1] and white matter[2]. The T2 decay curves were calculated as a finite sum of weighted exponentials and zero mean, Gaussian noise with standard deviation $\sigma$. The equilibrium magnetization, $M_o$, was 100. Data were calculated for variations in the SNR, defined as the ratio $M_o/\sigma$, the number of echoes, N, and the minimum available echo time, $TE_{min}$. The range in these parameters encompassed the experimental conditions typical in MR images, and extended toward the data quality achievable for *in vitro* experiments. For each set of experimental parameters, 100 trials were performed. In all cases, TE was chosen to provide appropriate sampling of the baseline.

Simulated data were fitted with T2NNLS to produce an estimate, $S'(T2_i)$, of the true T2 distribution, S(T2). The $T2_i$ were chosen as 100 values equally spaced on a logarithmic scale from 1 to 500 ms. Estimates of the mean and standard deviation of the T2 value and weighting of each component were calculated for every set of 100 trials.

Simulation results are shown in Fig. 1 for breast tissue with TE = 16 ms and N = 70, as a function of SNR. Results for SNR < 1000 show increasing inaccuracies in determining the correct number of relaxation components, and determining the T2 value and weighting of each component. These results are also influenced by the amount of constraint used in the fitting. For overconstrained fits, significant errors occur; for small amounts of constraint, there is an optimal value for each SNR that maximizes the percentage of admissible fits. At low values of SNR, an unconstrained least squares fit is better.

The results of this study provide a basis for the design of pulse sequences for *in vivo* measurement of multicomponent T2 relaxation. They suggest that current imaging techniques provide insufficient SNR and echoes for accurate multicomponent T2 relaxation analysis on a pixel-by-pixel basis. However, volume localization techniques that utilize hard pulses to measure T2 decay from a large volume of interest have potential for this type of analysis.

References

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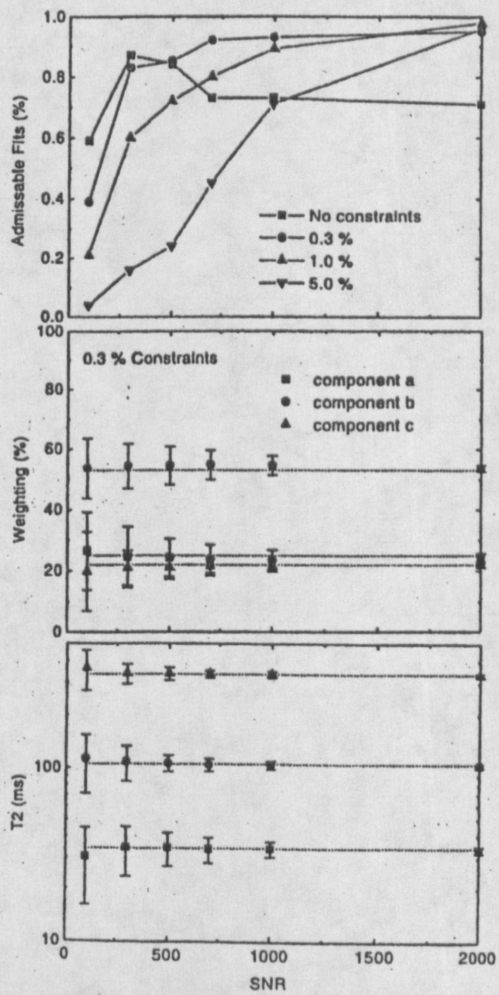


Fig. 1 The percentage of admissible fits containing 3 relaxation components, for several fitting constraints, as a function of SNR; for admissable fits, the estimated T2 and weighting for each component as a function of SNR (0.3 % constraints). Ideal values for each component are indicated by dashed lines.

(55.) Graham S., Stanchev P., Bronskill M., "Feasibility of Multicomponent T2 Relaxation Analysis using Data Measured on Clinical MR Scanners", ***Proceedings of the Society of Magnetic Resonance***, Second Meeting, August 1994, 848.